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(54) Title of Invention:
Active matrix panel

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(72) Inventor:
Hiroyuki Oshima
c/o Suwa Seikosha Co., Ltd.
3-5, Owa 3-chome, Suwa-shi

(71) Applicant:
Suwa Seikosha Co., Ltd.
3-4, Ginza 4-chome, Chuo-ku Tokyo

(74) Attorney: Patent Attorney Tsutomu Mogami

Specification

1. Title of Invention:
Active matrix panel

2. What is Claimed:

An active matrix panel comprising:

plural gate lines and plural source lines crossing perpendicular to said gate lines:

a thin film transistor utilizing a semiconductor thin film at each intersection of said gate lines and said source lines; and

a driver circuit constituted by a thin film transistor on at least one side of each of said gate lines or each of said source lines; and wherein:

a gate electrode of the thin film transistor located at each intersection of said gate lines and said source lines is formed either on the upper side or the lower side of said semiconductor thin film; and

the gate electrode of the thin film transistor used in said driver circuit is formed both on the upper side and the lower side of said semiconductor thin film.

3. Detailed Description of Present Invention:

The present invention relates to an active matrix panel utilizing thin film transistors (TFTs).

Much research is made on the formation of TFTs on insulating substrates lately. One of the goals of the research is formation of flat panel displays utilizing inexpensive insulating substrates. Specifically, it aims to manufacture flat panel displays such as liquid crystal displays (LCDs) by forming TFTs in a matrix structure on substrates and adapting the switching characteristics. Active matrix panels thus constituted could be manufactured at remarkably low costs.

When TFTs are utilized in active matrix panels, LCDs are generally comprised of glass substrates placed on the upper sides, TFT substrates placed on the lower sides and liquid crystals interposed in between. These LCDs display optional letters, figures and pictures by selecting liquid crystal driving elements arranged in matrix structures on said TFT substrates by external selective circuits and applying voltage to liquid crystal electrodes connected to said liquid crystal driving elements. Fig.1 shows a general structure of a circuit in said TFT substrates.

Fig.1 (a) shows the arrangement of liquid crystal driving elements in a matrix

structure on TFT substrates. Liquid crystal driving elements 2 are arranged in a matrix structure in the display region surrounded by Line 1. Lines 3 indicate data signal lines (source lines) for Liquid crystal driving elements 2, while Lines 4 indicate timing signal lines (gate lines) for Liquid crystal driving elements 2. Fig.1 (b) shows a circuit of Liquid crystal driving elements 2. A TFT indicated by 5 performs switching of data. A condenser indicated by 6 is used for holding data signals. A liquid crystal panel is indicated by 7, a liquid crystal driving electrode formed in accordance with each liquid crystal driving element by 7-1 and an upper glass panel by 7-2.

As described above, TFTs in the liquid crystal driving element are used to switch data on the voltage applied to the liquid crystals. Characteristics expected in TFTs of such an instance are classified into the following two categories:

(1) Efficiency to supply sufficient current to charge condensers when TFTs are in the ON-state

(2) Efficiency to minimize current when TFTs is in the OFF-state

Category (1) relates to writing characteristics of data stored into condensers. Because display by liquid crystals depends on the electric potential of condensers. TFTs must have efficiency of supplying sufficient current in order to completely write data in a short time. Current in such a case (hereinafter referred to as ON-state current) varies in accordance with the capacity of condensers and the time for writing. and TFTs must be manufactured in such a way that they can cope with such ON-state current.

Category (2) relates to retention characteristics. In general. written data must be held much longer than the writing time. Since capacities of condensers are usually as small as around 1pF, even if the current in OFF-state TFTs (hereinafter referred to as OFF-state current) is small, the electric potential of drains (the electric potential of condensers) become nearer to the electric potential of sources rapidly. making it impossible to hold written data correctly. Therefore, it is necessary to minimize OFF-state current in TFTs.

Heretofore, characteristics expected in TFTs of liquid crystal driving elements are described. Following is a description of characteristics expected in TFTs utilized to constitute peripheral circuits (hereinafter referred to driver circuits) for supplying signals to each gate line or each source line and driving each liquid crystal driving element.

About 200 gate lines and about 400 source lines are usually provided in one active matrix panel. and signals needed for each line must be supplied from the

exterior. When the external circuit is provided for this purpose, connection of about 400 terminals of gate lines, source lines and the external circuit becomes necessary in the active matrix panel. Therefore, it is preferable to form driver circuits on the panels simultaneously with liquid crystal driving elements. Such formation would realize sharp decrease in the number of terminals to be taken out from the active matrix panels to the exterior, specifically to approximately 10 lines. Fig.2 shows a structure of the active matrix panel in such an instance. The display region indicated by 8 corresponds to the area surrounded by Line 1 in Fig.1 (a) and comprises liquid crystal driving elements arranged in a matrix structure. Lines 9 are source lines and Lines 10 are gate lines. Signals to Source lines 9 are supplied from Data line 11 via Switch 12. ON-OFF of Switch 12 is operated by Source line driver circuit 13, which is composed of a shift resistor group. Timing signals to Gate lines 10 are directly supplied from Gate line driver circuit 14, which is also composed of a shift resistor group. It is necessary to operate the source line driver circuit at a high speed usually. For example, the driver circuit is operated at a frequency of around 4MHz in the case of performing playback of TV signals. For this reason, TFTs constituting source line driver circuits must have large ON-state current. OFF-state current does not arise any problems as long as it is not such large as to malfunction circuits. On the other hand, the gate line driver circuit again demands large ON-state current, since it drives gate lines of as long as several centimeters, though it does not have to be operated at a high speed. OFF-state current does not pose significant problems. Accordingly, large OFF-state current does not generate any specific problems on the side of sources and gates in TFTs constituting peripheral driver circuits, but characteristics of having the largest ON-state current possible are expected in such TFTs.

As it is described above, characteristics expected in TFTs of liquid crystal driving elements are different from those expected in TFTs of driver circuits. Conventionally, these characteristics were provided in TFTs by changing the size of transistors. Specifically, W/L, the ratio of channel width W and channel length L, was kept low in TFTs of liquid crystal driving elements and high in TFTs of driver circuits to provide characteristics expected in each types. However, this had a shortcoming of having excessively large sizes of transistors of driver circuits. For this reason, the area of driver circuits per each panel became extremely large, thereby decreasing production yield inside a panel sharply and increasing costs. Furthermore, a decrease in the size of liquid crystal driving elements to perform clearer displays shortened intervals between source lines and gate lines naturally, which made

miniaturization of driver circuits increasingly necessary and highlighted shortcomings of the conventional method.

The present invention eliminates such shortcomings with the purpose of realizing formation of active matrix panels having expected characteristics while decreasing areas of driver cuircuits. Namely, the present invention provides active matrix panels whose gate electrodes of TFTs in liquid crystal driving elements are formed either on the upper sides or the lower sides of semiconductor thin films and whose gate electrodes of TFTs in driver circuits are formed both on the upper sides and the lower sides of semiconductor thin films. Following is a detailed description of the present invention with reference to figures.

Fig.3 is an example of a cross-section of a TFT having a gate electrode only on the upper side of a semiconductor thin film (hereinafter referred to as a single gate TFT). An insulating substrate of glass or others is indicated by 15, a semiconductor thin film by 16, a source region by 17, a drain region by 18, a gate insulating film by 19, a gate electrode by 20, an interlevel insulating film by 21, a source electrode by 22, and a drain electrode by 23. TFTs of this structure cannot have such large ON-state current, but can have small OFF-state current. According to the experiment by the present applicant, ON-state current of several μA can be obtained with relative ease, even if transistors are decreased to the compact size of L x W = 10μm x 10μm. Current of this value is sufficient for writing data, when TFTs are utilized as switching transistors in liquid crystal driving elements. Moreover, as OFF-state current can be kept at around 10pA at this time, sufficiently low OFF-state current to have retention characteristics can be obtained. Therefore, these single gate TFTs are arguably the optimal switching transistors in liquid crystal driving elements. In addition, the same can be said in the structure wherein a gate electrode is formed on the lower side of a semiconductor thin film, though Fig.3 shows the structure wherein a gate electrode is formed on the upper side of a semiconductor thin film.

Fig.4 is an example of a cross-section of a TFT having gate electrodes both on the upper side and the lower side of a semiconductor thin film (hereinafter referred to as a double gate TFT). An insulating substrate of glass or others is indicated by 24, the first gate electrode by 25, the first insulating film by 26, a semiconductor thin film by 27, a source region by 28, a drain region by 29, the second gate insulating film by 30, the second gate electrode by 31, an interlevel insulating film by 32, a source electrode by 33, and a drain electrode by 34. Such double gate TFTs can increase both OFF-state current and ON-state current in the greater degrees compared with

single gate TFTs, for channels formed by inducing carriers are formed both on the upper layer and the lower layer of semiconductors. In simple calculations, values of approximately twice as much as those in single gate TFTs can be obtained both in ON-state current and OFF-state current. The present invention utilizes this double gate TFT in the driver circuit. Since double gate TFTs have ON-state current of as much as roughly double of those in single gate TFTs, they can minimize sizes of transistors to the half. Furthermore, though OFF-state current flows at as high as double probabilities, OFF-state current does not increase substantially, because sizes of transistors can be decreased to the half. That is, almost the same characteristics with conventional ones can be obtained in transistors of half sizes. As a result of this, the area of peripheral driver circuits per each panel can be reduced by roughly half.

Finally, single gate TFTs are utilized in TFTs of liquid crystal driving elements instead of double gate TFTs in spite of all for the following reasons. Utilization of double gate TFTs as TFTs of liquid crystal driving elements would be able to reduce sizes of transistors to the half and obtain more or less the same characteristics with those of single gate TFTs, but would not be able to practice reduce of transistor sizes to the half due to the limitation of patterning techniques. In other words, though the minimum patterning scale of such large substrates as active matrix panels is said to be around 10 μm, sufficient characteristics of TFTs used in liquid crystal driving elements have been already obtained in single gate TFTs having channel width W of 10 μm, and therefore it is pointless to make channel width W to 5 μm by further adopting double gate TFTs. Namely, channel length L must be doubled, as channel width W is limited to 10 μm or more due to the limitation of patterning techniques. For this reason, the area of transistors increases on the contrary. Therefore, it is pointless to adopt double gate TFTs as TFTs of liquid crystal driving elements, hence single gate TFTs must be utilized.

As it is mentioned heretofore, the present invention has superior effects of decreasing the area of peripheral driver circuits per each panel by roughly half without deteriorating characteristics by providing single gate TFTs in liquid crystal driving elements and double gate TFTs in peripheral driver circuits.

4. Brief Description of Figures:

Fig.1 is a general circuit in the case of utilizing TFTs in an active matrix panel. Fig.2 shows the overall configuration of an active matrix structure having built-in peripheral circuits. Fig.3 is an example of a cross-section of a single gate TFT. Fig.4

is an example of a cross-section of a double gate TFT.

Applicant Suwa Seikosha Co., Ltd.
Patent Attorney Tsutomu Mogami